The issue of interference with other in-band users is beyond the scope of this document. However, any rules developed regarding this issue will overlay those developed for public safety and cooperation at the boundaries of service areas. Since any operational system must meet all of the limitations imposed, operators can lmeet these specifications by lowering their base station and mobile transmit powers thereby increasing the size of the exclusion zone, or by employing intelligent antennas to ensure noninterference and smaller exclusion zones. The major effect of increasing base station peak directional average radiated power (see definition below) is to increase the coordination radii within which PCS operators must take into account all other users of the band.

3. Definitions

The following definitions are proposed:

Contiguous Service Area (CSA): the contiguous geographic area in which an operator is licensed to use allocated frequency bands for broadband PCS base station emissions.

Base Station (BS): a collection of BST's and BSA's (see below). This definition will coincide with the conventional definition of a base station with the exception of those cases where the operator chooses to operate physically distant power amplifiers in a phase coherent fashion.

Phase Coherent Transmitters: transmitters whose RF carriers are phase-locked as if they were deriving their local oscillators from the same source. Such systems are capable of directing more power into smaller sectors than the sum of individual transmitter output powers. Note that time-synchronous transmission systems which transmit simultaneously from multiple BSAs at different BSs are not necessarily phase coherent since different local oscillators can be employed at each BS.

Base Station Transmitter (BST): one or more RF power amplifiers that operate in overlapping frequency bands in a phase coherent fashion within a CSA.

Base Station Transmitter Average Power (BSTAP): the average RF power produced by a BST over any specified period in units of watts (W). In particular, BSTAP(30) is measured over a 30 minute averaging period. BSTAP(0) is measured over any period of continuous transmission and is the maximum RF power produced in that interval.

Base Station Antenna (BSA): the combination of all radiating elements connected to a particular BST. BSA's, or portions thereof, may be common to multiple BST's through the use of power combiners or similar devices.

Allocated Frequency Band (AFB): the combined width of the licensee's broadband PCS frequency allocations within a CSA. The units of AFB are hertz (Hz).

Average Radiated Power (ARP): the average base station radiated power in the AFB over any specified period in units of watts (W). In particular, ARP(30) is measured over 30 minute averaging periods. ARP(0) is measured over any period of continuous transmission and is the maximum radiated power in that interval. This quantity is measured as the sum of the powers delivered to the BSA from all BSTs measured at the BSA connectors.

Average Radiated Power Spectral Density (ARPSD): ARP divided by the AFB in units of watts per hertz (W/Hz). ARPSD(30) is ARP(30) divided by AFB. ARPSD(0) is ARP(0) divided by AFB.

Peak Directional Average Radiated Power (PDARP): the maximum over all directions of the average power radiated by all BSA's at a BS in units of watts per steradian (W/sr). A steradian is the dimensionless unit of solid angle which is one radian on a side. PDARP(30) is measured over a 30 minute interval. PDARP(0) is measured over any period of continuous transmission and is the maximum directional radiated power in that interval. PDARP can be calculated by first determining the maximum possible power gain of the BSA corresponding to each BST for all values of azimuth and elevation (N.B. for the purposes of this calculation, if a BSA is shared by multiple BST's, each BST is treated as though it had an independent identical copy of the BSA) yielding gain patterns in units of gain per steradian (1/sr). Next, the gain pattern for each BSA is multiplied by the BSTAP for its corresponding BST, yielding power patterns in units of watts per steradian. PDARP is the maximum over all azimuth and elevation values of the sum of these power patterns.

Peak Directional Average Radiated Power Spectral Density (PDARPSD): PDARP divided by the AFB in units of watts per steradian per Hertz (W/Hz/sr). PDARPSD(30) is ARP(30) divided by AFB. PDARPSD(0) is ARP(0) divided by AFB.

Minimum Safe Distance (MSD): The minimum safe distance between a person and a BS/BSA/BST as determined from the criteria set forth in IEEE C95.1-1991 which is a function of PDARP.

4. Proposed Broadband PCS Base Station Transmitter Power Limitations

4.1 Average Radiated Power Spectral Density

ARPSD(30) shall not exceed 40 uW/Hz at a base station. ARPSD(0) shall not exceed 400 uW/Hz at a base station. In addition, ARPSD(30) and ARPSD(0) shall be limited according to BSA height as follows:

Antenna Height (m)	Maximum ARPSD(30) (mW/Hz)	Maximum ARPSD(0) (mW/Hz)
1 - 10	0.004	0.04
10 - 40	0.010	0.10
40 -	0.040	0.40

4.2 Directional Average Radiated Power Spectral DensityPeak

PDARPSD(30) shall not exceed 4 mW/Hz/sr at a base station. PDARPSD(0) shall not exceed 40 mW/Hz/sr at a base station. In addition, PDARPSD(30) and PDARPSD(0) shall be limited according to BSA height as follows:

Antenna Height (m)	Maximum PDARPSD(30) (mW/Hz/sr)	Maximum PDARPSD(0) (mW/Hz/sr)
1 - 10	0.04	0.4
10 - 40	1.00	10.0
40 -	4.00	40.0

4.3 Service Area Boundaries

The predicted or measured median field strength at any location on the border of the PCS service area shall not exceed 47 dBuV/m unless the parties agree to a higher field strength (cf. Section 99.232, Appendix A, Second Report and Order).

4.4 Interference Protection

No changes to the interference protection rule given in Section 99.232, Appendix A, Second Report and Order as amended are recommended at this time.

4.5 Mobile Power Limits

Handheld mobile unit powers shall not exceed 340mW PDARP(2) (peak directional average radiated power over a two minute period) and shall not exceed 2W PDARP(0) (instantaneous peak directional radiated power).

A second class of mobile unit is permitted which subject to a minimum distance of 0.8 meters from user to antenna, is subject to a 12W PDARP(2) limitation, and a 120W PDARP(0) limitation. Note that the minimum safe distance at 2 GHz for a 120 W transmitter is 0.8 meters assuming it is "uncontrolled".

5. Discussion

5.1 Safety Considerations

The power limits were derived from calculations of RF exposure as a function of distance

from the BSA assuming the entire 120 MHz band was active at maximum power. This is naturally quite pessimistic since it requires all seven (7) operators to operate from the same location and have all their channels simultaneously active. The IEEE C95.1 1991 guidelines for RF exposure in an uncontrolled environment yield the minimum safe distances provided in the table below (see the figure below):

PDARPSD(30) (mW/Hz/sr)	Conservative Safe Distance (m)
0.04	5
1.00	25
4.00	50

These are boresight approach distances which, given the typical height of an antenna above the surrounding terrain, will be generally unattainable by the general public (even to within a factor of 2 or 3 in distance). The limits proposed for PDARPSD(30) are therefore quite conservative in light of the guidelines. The peak power limits, ARPSD(0) and PDARPSD(0), were somewhat arbitrarily set at 10 times the corresponding 30 minute values.

5.2 PDARP and EIRP

In essence, PDARP is obtained by divorcing the concept of channel bandwidth from the more conventional concept of EIRP. For a single-sector system employing BSA's with static gain patterns, the PDARP is simply the sum of the per-channel EIRP's. In systems employing BSA's with dynamic gain patterns, PDARP's will depend on user densities, exclusion zones and other parameters. The use of multiple transmitting elements per channel is relatively new, although it is employed in the GSM systems of several manufacturers.

5.3 ARP, PDARP and Antenna Gain

The conepts of ARP and PDARP are similar as mentioned earlier to total radiated power and EIRP respectively. In particular, PDARP/ARP is the peak antenna gain in dBi. The omnidiectional reference is a consequence of defining the ARP as nondirectional, i.e., with respect to an omnidirectional antenna. The ratio of the limits of these quantities varies from 10 to 100 as the antenna height increases. For low antenna heights, the probability on incidental physical contact is greater, so peak directional power is reduced to 10 times the average. For BSAs at greater heights, gains of 100 (or 20dB) are used. The choice of 20 dB was made on practical technical and economic bases.. Antennas with gains approaching 20 dB can be purchased and operated at reasonable cost, achieving 10 dB gain in azimuth and elevation.

The factor of ten (10) between ARP(0) and APR(30), for example, is based on engineering judgement and not RF instantaneous field strength limits or dosimetry calculations. As such information becomes available, these limits can be further refined.

5.4 Sample PCS Calculations

For 30 MHz PCS allocations, the maximum ARPSD(30) for antenna heights in excess of 50 meters corresponds to a 1.2 kilowatt (kW) limit on the power radiated by a base station. For example, assuming an antenna with 22 dBi gain (G=160), this 1.2 kW supports 120 1.6 kW EIRP carriers. Note that this link happens to be approximately balanced by a 2 W EIRP mobile unit assuming a 200kHz channel bandwidth per carrier and nominal values for base station receiver diversity gain and receiver sentivities (cf., the Telocator Petition for Reconsideration). Continuing with this scenario, the PDARPSD(30) limit corresponds to a base station peak directional average radiated power limit of 36 W/deg/deg. This accommodates only 75 carriers, which is therefore the limit in this case.

Note that this calculation is entirely channel bandwidth independent and therefore could apply to any proposed air interface. By coincidence, there are 75 200kHz paired channels in a 30 MHz allocation. If all channels carry 8 traffic channels such as DCS-1900, an omni cell could handle 600 simultaneous links.

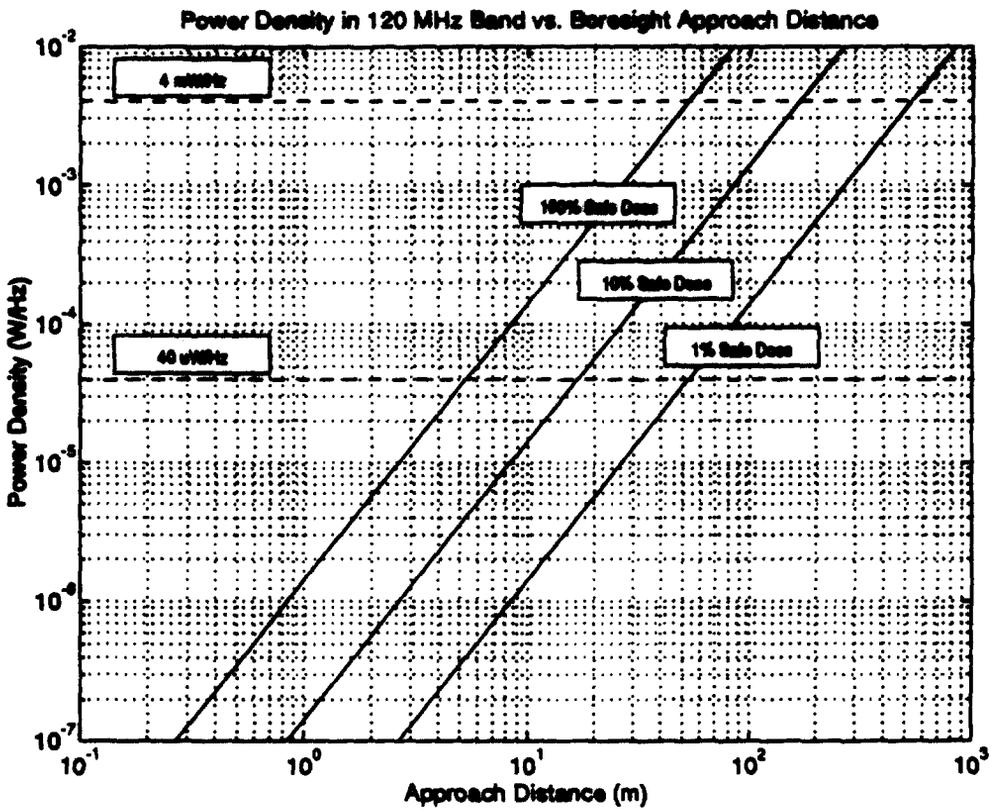
It is also important to note that while this 1.6 kW EIRP forward link is roughly balanced by a 2 W EIRP mobile unit, balancing of the links is not a requirement. Furthermore, balanced links should neither be imposed, nor be used as rationale for reducing base station power limits. There is a demonstrated market (e.g., paging and short-message services) for higher data rate one-way services which can benefit substantially from higher downlink EIRPs. Such service should not be precluded while the public is in no danger of RF exposure in excess of accepted limits.

5.5 Mobile Power Limits

The commission has adopted a 2W peak EIRP (in terms of the definitions contained herein, EIRP is PDARPSD(0) times the RF channel bandwidth) which in the absence of a limit on long-term average power treats mobile users unequally depending upon the particular modulation format. It is currently general practice to have handhelds with continuous transmission of 1W EIRP (0.6W transmitter into a 2dBi dipole antenna) as in the AMPS system today. Reflecting the increased RF transmission loss at 1.8GHz, a 2W limit would seem to be appropriate. This however is based on continuous transmission. Thus, an analog FM mobile user has 3 times the information carrying capacity of a 3-slot TDMA mobile user in the same RF bandwidth. In this case, 3-slot TDMA mobile users should be allowed the same time average power as analog FM user to be equitable. This implies that a 3-slot TDMA mobile should be allowed peak powers 3 times greater than the average analog FM power, assuming that such powers are within the appropriate exposure guidelines for handheld units. .

Equitable treatment of mobile users places limits on average power radiated based on long term radiation hazards. Short-term radiation limits should be used to set the peak power limits. Herein, we have assumed that peak power limits which are a factor of 10

greater than average power limits are within RF exposure guidlines. As indicated above, the minimum safe distance at 2 GHz for a 120 W transmitter is 0.8 meters assuming it is "uncontrolled". Therefore, in terms of average exposure, even the new class of mobile with 12 W ARP(2) is quite conservative.



IEEE C.95-1 1991 RF Exposure Limits at 2 GHz

CERTIFICATE OF SERVICE

I hereby certify that a copy of the foregoing Joint Comments Of Spatial Communications, Inc. and ArrayComm, Inc. were hand-delivered or mailed, first class, postage prepaid this 22nd day of April, 1994 to the following:

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1) I am President and Chief Technical Officer of ArrayComm, Inc. and President and Chief Technical Officer of Spatial Communications, Inc.

2) I have reviewed the foregoing comments. The attached technical exhibit was prepared under my supervision. The foregoing comments and technical exhibit are true and correct to the best of my knowledge and belief.

Richard Roy

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